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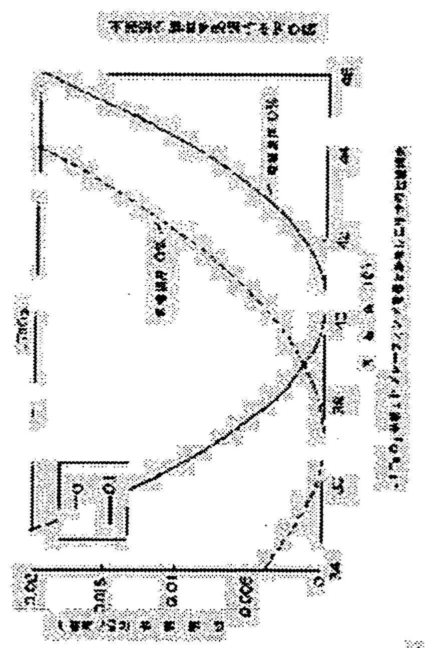
(54) SURFACE ACOUSTIC WAVE DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a surface acoustic wave device which has a wide bandwidth and is excellent in rectangularity ratio in a high frequency range in which the added mass effect of an Au or Cu electrode becomes conspicuous.
SOLUTION: The cut angle of the θ rotation Y-X substrate of $LiTaO_3$ or $LiNbO_3$ is optimized at an angle higher than that in the conventional practice with respect to the added mass of an Au or Cu electrode formed on a substrate surface.



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CLAIMS

[Claim(s)]
[Claim 1] Surface-acoustic-wave equipment characterized by being what characterized by providing the following. A piezo-electric substrate. In the surface-acoustic-wave equipment which consists of an electrode pattern which makes a principal component Au formed in the aforementioned piezo-electric substrate front face The aforementioned electrode pattern excites LSAW on the aforementioned piezo-electric substrate front face, and the aforementioned electrode pattern has the thickness of the range of 0.004-0.021 of the wavelength of the excited above LSAW. the aforementioned piezo-electric substrate The direction which made Z shaft orientations rotate LiTaO3 single crystal at the angle of 46 degrees or less from a Y-axis focusing on the X-axis more greatly than 39 degrees.
[Claim 2] Surface-acoustic-wave equipment characterized by being what characterized by providing the following. A piezo-electric substrate. In the surface-acoustic-wave equipment which consists of an electrode pattern which makes a principal component Cu formed in the aforementioned piezo-electric substrate front face The aforementioned electrode pattern excites LSAW on the aforementioned piezo-electric substrate front face, and the aforementioned electrode pattern has the thickness of the range of 0.009-0.045 of the wavelength of the excited above LSAW. the aforementioned piezo-electric substrate The direction which made Z shaft orientations rotate LiTaO3 single crystal at the angle of 46 degrees or less from a Y-axis focusing on the X-axis more greatly than 39 degrees.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Generally this invention relates to surface-acoustic-wave equipment, and is especially GHz. It is related with the surface-acoustic-wave equipment which has the passband property which was excellent in the high frequency band including a band.
[0002]
[Description of the Prior Art] Surface-acoustic-wave equipment is widely used as a filter or a resonator in the RF circuit of the radio communication equipment which operates by small and lightweight and very high frequency bands, such as a cellular phone. Although this surface-acoustic-wave equipment is generally formed on a piezo-electric single crystal or a polycrystal substrate Electromechanical coupling coefficient k2 It is large, the excitation efficiency of a surface wave is high, and it sets to a high frequency band. the propagation loss of a surface wave as a small substrate material It is especially $LiNbO_3$. In the 64-degree rotation Y cut board of a single crystal The propagation direction of a surface wave 64-degreeY-X $LiNbO_3$ made into the direction of X A substrate (K.Yamanouti and K.Shibayama, J.Appl.Phys.vol.43, no.3, March 1972, pp.856) or $LiTaO_3$ In the 36-degree rotation Y cut board of a single crystal It is 36-degreeY-X $LiTaO_3$, using the propagation direction of a surface wave as the direction of X. The substrate is used widely.
[0003]
[Problem(s) to be Solved by the Invention] However, these cut angles are addition of the electrode formed on the piezoelectric-crystal substrate. GHz needed with the latest cellular phone etc. In operation near the band, it becomes impossible to ignore to the elastic-wave wavelength by which the thickness of an electrode is excited, and does not necessarily become an optimum. In operation by such high frequency band, the effect of the additional mass of an electrode shows up notably. Very much, although it is possible to make small the pass band width of a surface-acoustic-wave filter or the capacity factor gamma of a surface-acoustic-wave resonator such by making the thickness of the electrode on a piezo-electric substrate increase in operation of a short wavelength region, and increasing the electromechanical coupling coefficient on appearance, with such composition, the problem on which the bulk wave emitted toward the interior of a substrate from an electrode increases, and the propagation loss of a surface wave increases arises. It is SSBW (surface skimming bulk wave) about this bulk wave. It calls and the surface wave accompanied by this SSBW is called LSAW (Leaky surface acoustic wave). About the propagation loss of LSAW in the surface-acoustic-wave filter using the thick electrode layer 36-degreeY-X $LiTaO_3$ And 64-degreeY-X $LiNbO_3$ About a substrate Others [Plessky /], or -- Edmonson By others Analysis is made (). [V.S.Plessky] and C.S.Hartmann, Proc.1993 IEEE Ultrasonics Symp., pp.1239-1242; P.J.Edmonson and C.K.Campbell, Proc.1994 IEEE Ultrosonic Symp., pp 75-79.
[0004] by the way, such conventional 36-degreeY-X $LiTaO_3$ Or 64-degreeY-X $LiNbO_3$ etc. -- with the conventional surface-acoustic-wave filter using LSAW, when electrode thickness is thin, the sonic value of a surface wave and the sonic value of a bulk wave approach, and,

as a result, the spurious peak by the bulk wave appears in the passband of a filter (M.Ueda et al., Proc.1994 IEEE Ultrasonic Symp., pp.143-146)
[0005] Drawing 20 is described above. Ueda In the surface wave filter by other reference, the spurious peaks A and B by the bulk wave which appeared near the filter pass band region are shown. A filter is 36-degreeY-X LiTaO3. It is constituted on a substrate and the Kushigata electrode which consists of an aluminum-Cu alloy with a thickness [equivalent to 3% of excitation wavelength] of 0.49 micrometers is formed.
[0006] The spurious peak B is 330MHz for referring to drawing 20 . Although generated out of the passband formed in near, the spurious peak A is understood that it is generated in the passband and the ripple has arisen in the passband property as a result.
[0007] It is GHz in order not to depend for the acoustic velocity of SSBW on the thickness of an electrode to depending for the acoustic velocity of a surface wave on the additional mass of an electrode, i.e., thickness, with a surface-acoustic-wave filter. In operation by high frequency band like a band, the thickness of an electrode increases to excitation surface wave wavelength, and the acoustic velocity of a surface wave falls relatively to a bulk wave. Consequently, the passband of a filter shifts to a spurious peak and a passband property carries out flattening. However, as it explained also in advance that the thickness of an electrode increased to surface wave wavelength in this way, loss of LSAW by bulk radiation will increase.
[0008] Moreover, it is especially GHz. In a surface-acoustic-wave filter like a band which operates by the high frequency band very much, although it is necessary to secure a certain amount of thickness to an electrode in order to decrease resistance of the Kushigata electrode, the increase of loss it was explained previously that became so, and the problem of degradation of a remanence ratio are not avoided.
[0009] Then, this invention sets it as the general purpose to offer the new and useful surface-acoustic-wave equipment which solved such a conventional trouble.
[0010] The more concrete purpose of this invention has the piezo-electric single crystal substrate started on the cut square optimized to the thickness of an electrode, and is to offer the surface-acoustic-wave equipment which avoided and set up spurious one which originates a passband in a bulk wave.
[0011]
[Means for Solving the Problem] In the surface-acoustic-wave equipment which consists of a piezo-electric substrate and an electrode pattern which makes a principal component Au formed in the aforementioned piezo-electric substrate front face as this invention indicated the aforementioned technical problem to the claim 1 The aforementioned electrode pattern excites LSAW on the aforementioned piezo-electric substrate front face, and the aforementioned electrode pattern has the thickness of the range of 0.004-0.021 of the wavelength of the excited above LSAW. the aforementioned piezo-electric substrate With the surface-acoustic-wave equipment characterized by being what has the direction which rotated LiTaO3 single crystal from a Y-axis to Z shaft orientations at the angle of 46 degrees or less focusing on the X-axis more greatly than 39 degrees Or as indicated to the claim 2, it sets to the surface-acoustic-wave equipment which consists of a piezo-electric substrate and an electrode pattern which makes a principal component Cu formed in the aforementioned piezo-electric substrate front face. The aforementioned electrode pattern excites LSAW on the aforementioned piezo-electric substrate front face, and the aforementioned electrode pattern has the thickness of the range of 0.009-0.045 of the wavelength of the excited above LSAW. the aforementioned piezo-electric substrate It solves with the surface-acoustic-wave equipment characterized by being what has the direction which rotated LiTaO3 single crystal from a Y-axis to Z shaft orientations at the angle of 46 degrees or less focusing on the X-axis more greatly than 39 degrees.
[0012] Hereafter, an operation of this invention is explained, referring to drawing 1 -3.
[0013] Drawing 1 is drawing explaining the logging angle of a piezoelectric-crystal substrate.
[0014] Drawing 1 is LiTaO3. The state where it started at the angle to which only the angle

of rotation theta leaned the piezo-electric single crystal [like] which has crystallographics axis X, Y, and Z to Z shaft orientations from the Y-axis around the crystallographic axis X is shown. Such a piezoelectric-crystal substrate is called a theta rotation Y-X substrate.
[0015] Drawing 2 is LiTaO3. The insertion loss of the resonator formed on the theta rotation Y-X substrate of a single crystal is shown about various logging angles or angles of rotation theta.
[0016] also in advance, it explained -- as -- the former -- LiTaO3 the case where surface-acoustic-wave equipment is formed on a substrate -- 36 degreeY-X substrate -- moreover, LiNbO3 although 64-degreeY-X substrate is generally used when forming surface-acoustic-wave equipment on a substrate, this can disregard the additional-mass effect of the electrode formed on a substrate front face -- comparatively -- a long wave -- the propagation loss to merit's surface wave is based on the minimum and a bird clapper by these angles of rotation For example, Shingaku Giho besides Nakamura, 77 to US42 reference.
[0017] The curve shown by the black dot among drawing 2 is LiTaO3. It is what calculated the propagation loss of LSAW when thickness forms the imagination electrode of zero in 36-degreeY-X substrate front face uniformly, and when an angle of rotation theta is 36 degrees, a bird clapper understands a propagation loss at the minimum. however -- this calculation -- Kovacs others -- the constant of the reported crystal was used (G.Kovacs, et al., Proc.1990 IEEE Ultrasonic Symp.pp.435-438)
[0018] However, GHz In a short wavelength field like a band, as explained also in advance, it becomes impossible to ignore to the wavelength of the surface wave by which the thickness of an electrode is excited, and the effect of the additional mass of an electrode shows up notably. the artificer of this invention found out what the propagation-loss property of drawing 2 changes with the effects of this additional mass in the direction of an arrow, and the angle of rotation theta which does the minimum propagation loss to drawing 2 as with a circle [white] showed shifts to the degree side of angle of elevation However, the curve shown with a circle [white] shows the case where the thickness of an electrode is moreover 10% of the wavelength of an excitation surface wave, by the case where aluminum electrode is uniformly formed on a piezo-electric substrate, among drawing 2 .
[0019] Furthermore, it is LiTaO3 to drawing 3 . The propagation loss at the time of forming on a substrate the grating electrode which consists of aluminum, and the relation of an angle of rotation theta are shown. However, a solid line shows the case where electrode thickness is 10% of excitation surface wave wavelength when a dashed line is electrode layer thick zero, among drawing 3 . Clearly, as a result of forming the grating of limited thickness to the wavelength of an excitation surface wave on a substrate, the angle of rotation from which a propagation loss becomes the minimum has shifted to the degree side of angle of elevation.
[0020] Namely, LiTaO3 By setting the angle of rotation theta of a single crystal substrate as the degree of angle of elevation rather than conventional 36 degrees, it is GHz. There is little attenuation of a surface wave in a band, and Q can form high surface-acoustic-wave equipment. Moreover, addition of the electrode in such high frequency As explained also in advance, the spurious peaks A and B do not originate in a bulk wave, and are not influenced of the additional mass of an electrode.
[0021] Moreover, the remanence ratio of a passband property also changes with angles of rotation theta in this invention, and it is especially GHz. LiTaO3 started at the angle higher than the angle of rotation theta currently used conventionally in a band Giving pass band width and a remanence ratio excellent in the substrate was found out. Drawing 4 and 5 are this LiTaO3, respectively. The frequency temperature characteristic of the surface-acoustic-wave filter formed on the substrate and the temperature characteristic of the minimum insertion loss are shown. However, the thing of the composition of drawing 7 explained later is used for a surface-acoustic-wave filter, and it is LiTaO3 of various angles of rotation theta. On the substrate, it formed so that it might become 10% of the wavelength of the surface acoustic wave by which electrode thickness is excited.

[0022] the case where the angle of rotation theta of a substrate of a filter, i.e., a cut angle, is any of 36degreeY, 40degreeY, 42degreeY, and 44 degreeY so that drawing 4 may show -- abbreviation -- the same temperature characteristic is shown It is thought the thing resulting from the difference in the acoustic velocity in a substrate, and dispersion of sample production conditions that center frequency is changing variously.
[0023] Moreover, it is LiTaO3 so that drawing 5 may show. When the angle of rotation theta of a substrate is set as the range of 40 degrees Y-44 degreeY, loss decreases at least rather than the case where an angle of rotation theta is set as the conventional 36 degreeY, by the usual temperature requirement, i.e., the range of -35 degrees C-85 degreeC. When an angle of rotation theta is especially set as the range of 40 degrees Y-42 degreeY, it turns out that the range of fluctuation of the minimum insertion loss also decreases.
[0024] Moreover, drawing 6 is LiNbO3. The insertion loss of the resonator formed on the theta rotation Y-X substrate of a single crystal is shown about various logging angles or angles of rotation theta.
[0025] The curve shown with the dashed line among drawing 6 is LiNbO3. It is what calculated the propagation loss of LSAW when thickness forms the imagination electrode of zero in 64-degreeY-X substrate front face uniformly, and when an angle of rotation theta is 64 degrees, a bird clapper understands a propagation loss at the minimum. However, the constant of the crystal reported by Warner etc. was used in this calculation (J.Acoust.Soc.Amer., 42, 1967, pp.1223-1231).
[0026] However, GHz In a short wavelength field like a band, as explained also in advance, it becomes impossible to ignore to the wavelength of the surface wave by which the thickness of an electrode is excited, and the effect of the additional mass of an electrode shows up notably. the artificer of this invention found out what the propagation-loss property of drawing 6 changes with the effects of this additional mass in the direction of an arrow, and drawing 2 and the angle of rotation theta which does the minimum propagation loss to 3 as the solid line showed shift to the degree side of angle of elevation However, the curve shown as the solid line shows the case where the thickness of an electrode is 3% of the wavelength of an excitation surface wave, among drawing 2 .
[0027] Namely, LiNbO3 By setting the angle of rotation theta of a single crystal substrate as the degree of angle of elevation rather than conventional 64 degrees, it is GHz. There is little attenuation of a surface wave in a band, and Q can form high surface-acoustic-wave equipment.
[0028] LiTaO3 When forming an electrode by Au on a substrate, for the thickness of an electrode, 0.4 - 2.1% of range of wavelength is LiNbO3 further. When forming an electrode by Au on a substrate, as for the thickness of an electrode, it is desirable to set it as 0.5 - 1.7% of range of wavelength. Moreover, LiTaO3 It is LiNbO3 further to set it as 0.9 - 4.5% of range of wavelength, in forming an electrode by Cu on a substrate. When forming an electrode by Cu on a substrate, it is desirable to set it as 1.2 - 3.6% of range of wavelength.
[0029]
[Embodiments of the Invention] Hereafter, this invention is explained in detail about a desirable example.
[0030] The plan and drawing 7 (B) which show the composition of the ladder type surface-acoustic-wave filter according [drawing 7 (A)] to the 1st example of this invention are the representative circuit schematic.
[0031] drawing 7 (A) -- referring to -- a surface-acoustic-wave filter -- LiTaO3 Or LiNbO3 1st Kushigata electrode R1 by which it was formed on the rotation Y cut of a single crystal, and the input-side electrode was connected to the input terminal IN An input-side electrode is the aforementioned Kushigata electrode R1. 2nd Kushigata electrode R1' by which connected with the output side electrode and the output side electrode was further connected to the output terminal OUT, an input-side electrode -- Kushigata electrode R1 3rd Kushigata electrode R2 which it connected [3rd] with the input-side electrode and had the output side electrode grounded an input-side electrode -- Kushigata electrode R1 an

output side -- an electrode -- connecting -- having -- an output side -- an electrode -- grounding -- having had -- the -- four -- Kushigata -- an electrode -- R -- two -- ' -- an input side -- an electrode -- Kushigata -- an electrode -- R -- one -- ' -- an output side -- an electrode -- connecting -- having -- an output side -- an electrode -- grounding -- having had -- the -- four -- Kushigata -- an electrode -- R -- two -- " -- containing .
[0032] each Kushigata electrode R1, R1', R2, R2', and R2 -- " -- setting -- the input-side electrode i -- The electrode finger of the 1st group which extends in parallel mutually in the 1st direction which intersects the path of the surface acoustic wave spread to X shaft orientations as usual is included. Moreover, the electrode finger of the 1st group and the electrode finger of the 2nd group are arranged by turns including the electrode finger of the 2nd group with which the output side electrode o extends in parallel with the 2nd direction opposite to the 1st direction of the above as usual. furthermore -- each -- Kushigata -- an electrode -- R -- one -- R -- one -- ' -- R -- two -- R -- two -- ' -- R -- two -- " -- **** -- X -- shaft orientations -- a top -- both sides -- plurality -- being parallel -- an electrode -- a finger -- ends -- connecting too hastily -- having made -- composition -- a reflector -- Re -- forming -- having -- **** . this example -- **** -- Kushigata -- an electrode -- R -- one -- R -- one -- ' -- R -- two -- R -- two -- ' -- R -- two -- " -- aluminum - one -- % -- Cu -- an alloy -- forming -- having -- a filter -- a passband -- wavelength -- ten -- % -- corresponding -- about -- 0.4 -- micrometer -- thickness -- forming -- having -- **** .
[0033] Drawing 7 (B) shows the representative circuit schematic of the filter of drawing 6 (A).
[0034] It is the Kushigata electrode R1 for referring to drawing 7 (B). And the series connection of R1' is carried out, and parallel connection of the Kushigata electrode R2, R2', and R2" is carried out further.
[0035] Drawing 8 is the minimum insertion loss experimentally obtained about the surface-acoustic-wave filter of drawing 7 (A) and (B) LiTaO3 Various cut angles theta of the single crystal substrate 11 are shown. Although the minimum insertion loss includes the effect of the both sides of the propagation loss of a surface wave, and adjustment loss of a filter, the cut angle theta of a substrate does not contribute to adjustment loss substantially.
[0036] With reference to drawing 8 , the minimum insertion loss decreases as the cut angle of a substrate increases, and in a nearly 42-degree cut angle, the minimum and a bird clapper understand it. If a cut angle exceeds 42 degrees, the minimum insertion loss will increase again. Therefore, it is LiTaO3 from a viewpoint of a filter insertion loss. By setting the cut angle of a substrate 11 as the range of 38 to 46 degrees, the minimum insertion loss of a filter can be stopped within 1.6dB.
[0037] At this invention, it is LiTaO3. It was found out that the cut angle of a single crystal substrate also influences the remanence ratio of a surface-acoustic-wave filter.
[0038] Drawing 9 (A) shows the definition of a remanence ratio.
[0039] With reference to drawing 9 (A), a remanence ratio is the bandwidth BW2 which gives 1.5dB attenuation to the minimum insertion loss of a passband. Bandwidth BW1 which gives 20dB attenuation It uses and they are BW1 / BW2. It is given. As for a passband, width of face decreases at the same time a filter becomes broadcloth and a selection ratio deteriorates so that a remanence ratio is large. That is, as for a remanence ratio, it is desirable to design a surface-acoustic-wave filter so that 1 may be approached as much as possible.
[0040] Drawing 9 (B) shows the remanence ratio experimentally obtained about the surface-acoustic-wave filter of drawing 7 (A) and (B) as a function of the cut angle theta of the piezo-electric substrate 11.
[0041] A remanence ratio approaches 1 as the cut angle theta increases, and reaches the minimum value 1.47 on a theta= 42-degree cut square so that drawing 9 (B) may show. On the other hand, if a cut angle increases exceeding 42 degrees, a remanence ratio will also increase and the selectivity of a filter will deteriorate. It is desirable for the minimum

insertion loss to be 1.6dB or less, and for a remanence ratio to be 1.55 or less with the surface-acoustic-wave filter by this invention, therefore it is LiTaO3 from drawing 9 (B). As a cut angle theta of a substrate, it turns out especially are the range of 39-46 degrees, and that the range of 40-44 degrees is desirable. By setting the cut angle theta as 42 degrees especially, the minimum insertion loss can be minimized and a remanence ratio can also be minimized.

[0042] Drawing 10 shows the passband property experimentally acquired about drawing 7 (A) and (B) surface-acoustic-wave filter. The inside of drawing 10 and a solid line are LiTaO3. When 42-degreeY-X substrate is used as a substrate 11, an one-point dashed line is same LiTaO3. The case where 36-degreeY-X substrate is used as a substrate 11 is shown.

[0043] A passband property is 880MHz for referring to drawing 10 . It has center frequency and is about 40MHz. It characterizes by the flat passband. It is ** with the filter steeper than the thing using the conventional 36-degreeY-X substrate although attenuation increases rapidly using 42-degreeY-X substrate out of a passband. It turns out that a sex, therefore the more excellent remanence ratio are shown. Moreover, in drawing 10 , the spurious peaks A and B which originate out of the passband of a filter at SSBW are observed.

[0044] Drawing 11 is LiTaO3. Electromechanical coupling coefficient k2 at the time of forming in Y rotation X cut substrate front face the electrode whose thickness to the wavelength of a surface acoustic wave is 7% The result calculated about various cut angles theta is shown. calculation -- Kovacs others (above) -- the reported crystal constant was used

[0045] It is an electromechanical coupling coefficient k2 for referring to drawing 11 . It turns out that the inclination which decreases with increase of a cut angle is shown. Electromechanical coupling coefficient k2 It is the amount which shows the rate of the energy accumulated by piezoelectricity effect in piezoelectric crystal as everyone knows, and the problem which pass band width will decrease if this value is small, or a ripple produces in a passband arises. From drawing 11 , the cut angle theta is understood that it is desirable to set it as 46 degrees or less too.

[0046] Drawing 12 is LiTaO3 formed on various cut squares in the filter of drawing 7 (A) and (B). The result which calculated the propagation loss at the time of changing the thickness of the Kushigata electrode formed on the Y rotation-X propagation substrate 11 is shown. calculation of drawing 12 -- also setting -- previous calculation -- the same -- Kovacs others -- the crystal constant was used

[0047] When a cut angle is 38 degrees or less so that drawing 12 may show, although loss increases in monotone exponentially with increase of electrolyte thickness, if a cut angle exceeds 40 degrees, loss will begin reduction with the thickness of an electrode, and it is understood that a dot appears very much in a characteristic curve. If it passes over a dot very much, loss will start to increase again. When the cut angle of a substrate 11 is especially set as the range of 40 to 46 degrees which is the desirable angle explained previously, such a minimum point appears at the place whose thickness of the electrode to wavelength is 3% or more. When it puts in another way, in the filter of this example, it is desirable to form so that the thickness which standardized the electrode on wavelength may become 3% or more. On the other hand, if the thickness of an electrode becomes excessive, in order for patterning by etching of an electrode to become difficult or for the acoustic velocity in a substrate to change with the thickness of an electrode sensitively, as for an electrode, it is desirable to form so that it may be thin to less than 15% to wavelength. Although it turns out that a propagation loss will increase rapidly also in which cut angle from drawing 12 if the thickness of an electrode exceeds 15% of wavelength in the case of the electrode using the aluminum or aluminum-1%Cu alloy, as for this, radiation of the bulk wave from an electrode shows the bird clapper predominantly. the range especially whose cut angle is 39-46 degrees -- the thickness of an electrode -- the range of 0.07-0.15 -- moreover, as for the thickness of an electrode, it is desirable that the ranges of a cut angle are 0.05-0.10 in the range of 40 to 44 degrees

[0048] Drawing 13 is LiNbO3 formed on various cut squares in the filter of drawing 7 (A) and

(B). A Y rotation-X cut is used as a substrate 11, and the result which calculated the propagation loss at the time of changing the thickness of the Kushigata electrode formed on the substrate 11 to the wavelength of an excitation surface acoustic wave is shown. However, by calculation of drawing 13 , it is the point. Warner Other crystal constants are used.
[0049] As drawing 13 shows, although a propagation loss increases exponentially once it takes the minimal value with increase of electrode thickness, by the angle of rotation 64 degrees or less currently used conventionally, a bird clapper understands a propagation loss for it in the place whose electrode thickness to wavelength is 3.5% or less at the minimum. However, if electrode thickness increases further and exceeds 4% of the wavelength of an excitation surface acoustic wave in this case, a propagation loss will increase rapidly. On the other hand, when the cut angle of a substrate is set as 66 degrees or more, for a propagation loss, electrode thickness is addition of 4% or more of an excitation surface acoustic wave, i.e., an electrode. When it puts in another way, under the conditions which electrode thickness from which the electrode thickness standardized on wavelength becomes 4% or more cannot disregard to the wavelength of an excitation surface acoustic wave, it is LiNbO3. It is desirable to set the cut angle of a substrate as 66 degrees or more. On the other hand, if the thickness of an electrode becomes excessive, in order for patterning by etching of an electrode to become difficult or for the acoustic velocity in a substrate to change with the thickness of an electrode sensitively, as for an electrode, it is desirable to form so that it may be thin to less than 12% to wavelength. It follows on this and is LiNbO3. As for the cut angle of a substrate, it is desirable to set it as the range of 66 to 74 degrees.
[0050] In each above example, although electrode composition was made into aluminum-1% Cu, a relation with the same said of pure aluminum is materialized. Moreover, LiTaO3 When forming an electrode by other electrode materials, for example, Au, on a substrate, for the thickness of an electrode, 0.4 - 2.1% of range of wavelength is LiNbO3 further. When forming an electrode by Au on a substrate, as for the thickness of an electrode, it is desirable to set it as 0.5 - 1.7% of range of wavelength. Moreover, it is LiNbO3 further to set it as 0.9 - 4.5% of range of wavelength, in forming an electrode by Cu on LiTaO3 substrate. When forming an electrode by Cu on a substrate, it is desirable to set it as 1.2 - 3.6% of range of wavelength.
[0051] Drawing 14 (A) shows the example of a changed completely type of the surface-acoustic-wave filter of drawing 7 (A), and drawing 14 (B) shows the representative circuit schematic. However, the same reference mark is given to the portion explained previously among drawing 14 (A) and (B), and explanation is omitted.
[0052] drawing 14 (A) -- referring to -- a surface-acoustic-wave filter -- the example of previous drawing 7 (A) -- the same -- LiTaO3 Or LiNbO3 1st Kushigata electrode R1 by which it was formed on the rotation Y cut of a single crystal, and the input-side electrode was connected to the input terminal IN An input-side electrode is the aforementioned Kushigata electrode R1. 2nd Kushigata electrode R1' by which connected with the output side electrode and the output side electrode was further connected to the output terminal OUT, It is the Kushigata electrode R1 about an input-side electrode. 4th Kushigata electrode R2 which it connected [4th] with the output side electrode, and 3rd Kushigata electrode R2' which had the output side electrode grounded, and the input-side electrode were connected [4th] to the output side electrode of Kushigata electrode R1', and had the output side electrode grounded It contains.
[0053] It is the Kushigata electrode R1 for referring to drawing 14 (B). And the series connection of R1' is carried out, and parallel connection of the Kushigata electrode R2 and R2' is carried out further. However, the Kushigata electrode R1, R1', R2, and R2' form vibrator, respectively, and Kushigata electrode R1' is R1. It has about 1/of capacity of 2. On the other hand, Kushigata electrode R2' is the Kushigata electrode R2. It has a twice [about] as many capacity as this.
[0054] Such a surface-acoustic-wave filter of composition is also LiTaO3 to a substrate. When it uses, more preferably an angle of rotation theta by setting it as about 42 degrees

most preferably 40 degrees or more 46 degrees or less 38 degrees or more 46 degrees or less Moreover, it is LiNbO3 to a substrate. It is addition of the electrode on a substrate by setting more preferably 66 degrees or more 74 degrees or less of angles of rotation theta as about 68 degrees, when it uses.

[0055] By the way, this example is not limited to the above-mentioned ladder type surface-acoustic-wave filter, and can be applied also to other surface-acoustic-wave filters, resonators, or propagation delay lines of a type. For example, the lattice type filter which transforms the filter of drawing 14 (A) and (B), and is shown in drawing 15 can be formed.

[0056] Drawing 16 shows the composition of the surface-acoustic-wave filter 30 by the 2nd example of this invention. With reference to drawing 16 , the surface-acoustic-wave filter 30 is the Y rotation XLiTaO3 whose cut angle explained previously is 38-46 degrees. Y rotation XLiNbO3 a board or whose cut angle is 66-74 degrees It is formed on the substrate which consists of a board, and is LiTaO3. When a substrate is used, the Kushigata electrode which has the thickness of 3 - 15% of range of wavelength is formed. Moreover, LiNbO3 When you use a substrate, let thickness of the Kushigata electrode be 4 - 12% of range of wavelength. Also in this example, as a surface wave, LSAW is excited and the excited surface wave is spread to X shaft orientations.

[0057] 30 has the composition which adjoined and arranged the Kushigata electrode Rin of a couple, and Rout, and the surface-acoustic-wave filter is arranging the reflector Re of a couple in the outside further. Also in this composition, by optimizing the cut angle of a substrate, and the thickness of an electrode like the equipment of drawing 7 (A) and (B), loss is minimized and the filter which has the latus passband property whose remanence ratio improved is obtained.

[0058] Drawing 17 shows the composition of the surface-acoustic-wave resonator 40 by the 3rd example of this invention.

[0059] With reference to drawing 17 , the surface-acoustic-wave resonator 40 is the Y rotation XLiTaO3 whose cut angle explained previously is 38-46 degrees. Y rotation XLiNbO3 a board or whose cut angle is 66-74 degrees It is formed on the substrate 11 which consists of a board, and is LiTaO3. When a substrate is used, the Kushigata electrode which has the thickness of 3 - 15% of range of wavelength is formed. On the other hand, it is LiNbO3. When a substrate is used, the Kushigata electrode which has the thickness of 4 - 12% of range of wavelength is formed. Also in this example, as a surface wave, LSAW is excited and the excited surface wave is spread to X shaft orientations.

[0060] The surface-acoustic-wave filter 40 has the Kushigata electrode Rin arranged in the Kushigata electrode Rout and its both sides, and is arranging the reflector Re of a couple in the outside further. In that case, the Kushigata electrode Rin is connected to an input terminal 41, and, on the other hand, the Kushigata electrode Rout is connected to an output terminal 42.

[0061] The resonator which has Q factor with loss high at the minimum by this composition by optimizing the cut angle of a substrate and the thickness of an electrode like the equipment of drawing 7 (A) and (B) is obtained.

[0062] Drawing 18 shows the composition of 1 port surface-acoustic-wave resonator 50 by the 4th example of this invention.

[0063] With reference to drawing 18 , the surface-acoustic-wave resonator 50 is the Y rotation XLiTaO3 whose cut angle explained previously is 38-46 degrees. Y rotation XLiNbO3 a board or whose cut angle is 66-74 degrees It is formed on the substrate 11 which consists of a board, and is LiTaO3. When it uses for a substrate, on the substrate 11, the Kushigata electrode which has the thickness of 3 - 15% of range of wavelength is formed. On the other hand, it is LiNbO3. When a substrate is used, on a substrate 11, the Kushigata electrode which has the thickness of 4 - 12% of range of wavelength is formed. Also in this example, as a surface wave, LSAW is excited and the excited surface wave is spread to X shaft orientations.

[0064] Other near electrodes are connected to the 1st terminal 51 for the near electrode of

1 which the surface-acoustic-wave resonator 50 consists of reflectors Re of the couple arranged in the single Kushigata electrode R formed on the aforementioned substrate, and its both sides, and constitutes the aforementioned Kushigata electrode R again at the 2nd terminal 52.
[0065] The resonator which has Q factor with loss high at the minimum by this composition by optimizing the cut angle of a substrate and the thickness of an electrode like the equipment of drawing 7 (A) and (B) is obtained.
[0066] Drawing 19 shows the composition of 2 port surface-acoustic-wave resonator 60 by the 5th example of this invention.
[0067] With reference to drawing 19 , the surface-acoustic-wave resonator 60 is the Y rotation XLiTaO3 whose cut angle explained previously is 38-46 degrees. Y rotation XLiNbO3 a board or whose cut angle is 66-74 degrees It is formed on the substrate 11 which consists of a board, and is LiTaO3. When it uses for a substrate, on the substrate 11, the Kushigata electrode which has the thickness of 3 - 15% of range of wavelength is formed. On the other hand, it is LiNbO3. When a substrate is used, on a substrate 11, the Kushigata electrode which has the thickness of 4 - 12% of range of wavelength is formed. Also in this example, as a surface wave, LSAW is excited and the excited surface wave is spread to X shaft orientations. The surface-acoustic-wave resonator 60 is the Kushigata electrode R1 of the couple connected to the input terminal 61 and the output terminal 62, respectively, and R2. It has and the reflector Re of a couple is further arranged in the outside. A resonator 60 is the Kushigata electrode R1. The 1st terminal 61 connected to the 1st electrode ****, and Kushigata electrode R2 It drives by impressing voltage between the 2nd terminal 62 connected to the 1st electrode ****. In addition, Kushigata electrode R1 The 2nd electrode **** and Kushigata electrode R2 The 2nd electrode **** is grounded.
[0068] The resonator which has Q factor with loss high at the minimum by this composition by optimizing the cut angle of a substrate and the thickness of an electrode like the equipment of drawing 7 (A) and (B) is obtained.
[0069] The surface-acoustic-wave equipment of this invention is still more useful also to the surface-acoustic-wave delay line or the waveguide which is not limited to the surface-acoustic-wave filter and surface-acoustic-wave resonator which were explained previously, and has the same composition.
[0070]
[Effect of the Invention] According to the feature of this invention of a claim 1 and two publications, they are the LiNbO3 aforementioned substrate or LiNbO3. By changing the cut angle of a substrate to the degree side of angle of elevation conventionally, and optimizing to the wavelength of LSAW which has electrode thickness excited further When Au or Cu is used as an electrode material, it becomes possible to minimize loss of surface-acoustic-wave equipment, to raise bandwidth, and to raise a square shape ratio further.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing 1 is drawing explaining the logging angle of a piezo-electric single crystal substrate.
[Drawing 2] It is drawing explaining the principle of this invention.
[Drawing 3] It is another drawing explaining the principle of this invention.
[Drawing 4] LiTaO3 of various cut angles It is drawing showing the temperature dependence of the formed surface-acoustic-wave filter, especially the temperature dependence of center frequency about a substrate.
[Drawing 5] LiTaO3 of various cut angles It is drawing showing the temperature dependence of the formed surface-acoustic-wave filter, especially the temperature dependence of the minimum insertion loss about a substrate.
[Drawing 6] LiNbO3 It is drawing showing the propagation loss of the surface-acoustic-wave filter formed on the substrate as a function of the cut angle of a substrate.
[Drawing 7] (A) and (B) are drawing which explains the composition of the surface-acoustic-wave filter by the 1st example of this invention, respectively, and its representative circuit schematic.
[Drawing 8] It is drawing explaining the relation between the minimum insertion loss of the surface-acoustic-wave filter of drawing 7 , and the cut angle of the piezo-electric substrate which constitutes a filter.
[Drawing 9] Drawing where (A) explains the definition of the remanence ratio in a filter pass band region property, and (B) are drawings explaining the relation between a remanence ratio and a substrate cut angle.
[Drawing 10] It is drawing explaining the passband property of the filter shown in drawing 7 (A) and (B).
[Drawing 11] LiTaO3 in the filter shown in drawing 7 (A) and (B) It is drawing explaining the relation between the substrate cut angle at the time of using a substrate, and an electromechanical coupling coefficient.
[Drawing 12] It sets in the filter shown in drawing 7 (A) and (B), and is LiTaO3. It is drawing showing the effect of the electrode thickness to the propagation loss at the time of using a substrate about various substrate cut angles.
[Drawing 13] It sets in the filter shown in drawing 7 (A) and (B), and is LiNbO3. It is drawing showing the effect of the electrode thickness to the propagation loss at the time of using a substrate about various substrate cut angles.
[Drawing 14] (A) and (B) are drawing which explains the composition of the surface-acoustic-wave filter by the example of a changed completely type of the 1st example of this invention, respectively, and its representative circuit schematic.
[Drawing 15] It is the representative circuit schematic of the surface-acoustic-wave filter by the example of a changed completely type of drawing 14 .
[Drawing 16] It is drawing showing the composition of the surface-acoustic-wave filter by the 2nd example of this invention.
[Drawing 17] It is drawing showing the composition of the surface-acoustic-wave resonator

by the 3rd example of this invention.
[Drawing 18] It is drawing showing the composition of 1 port surface-acoustic-wave resonator by the 4th example of this invention.
[Drawing 19] It is drawing showing the composition of 2 port surface-acoustic-wave resonator by the 5th example of this invention.
[Drawing 20] It is drawing showing the example of the passband property of conventional surface-acoustic-wave equipment.
[Description of Notations]
10, 30, 40, 50, 60 Surface acoustic element
11 Piezo-electric Substrate
31, 41, 51, 61 Input terminal
32, 42, 52, 62 Output terminal
R1, R1', R2, an R2' Kushigata electrode
Re Reflector

[Translation done.]